

Preprocessing for Eddy Dissipation Rate and TKE Profile Generation

J. Allen Zak
Vigyan, Inc., Hampton, Virginia

William G. Rodgers, Jr.
Lockheed Martin, Hampton, Virginia

The NASA STI Program Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- **TECHNICAL PUBLICATION.** Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA counterpart of peer-reviewed formal professional papers, but having less stringent limitations on manuscript length and extent of graphic presentations.
- **TECHNICAL MEMORANDUM.** Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.
- **CONTRACTOR REPORT.** Scientific and technical findings by NASA-sponsored contractors and grantees.

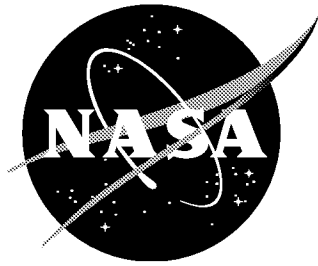
- **CONFERENCE PUBLICATION.** Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or co-sponsored by NASA.
- **SPECIAL PUBLICATION.** Scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial public interest.
- **TECHNICAL TRANSLATION.** English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results ... even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at <http://www.sti.nasa.gov>
- E-mail your question via the Internet to help@sti.nasa.gov
- Fax your question to the NASA STI Help Desk at (301) 621-0134
- Phone the NASA STI Help Desk at (301) 621-0390
- Write to:
NASA STI Help Desk
NASA Center for Aerospace Information
7121 Standard Drive
Hanover, MD 21076-1320

NASA / CR-2001-210834



Preprocessing for Eddy Dissipation Rate and TKE Profile Generation

J. Allen Zak
Vigyan, Inc., Hampton, Virginia

William G. Rodgers, Jr.
Lockheed Martin, Hampton, Virginia

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

Prepared for Langley Research Center
under Contract NAS1-96014

March 2001

Available from:

NASA Center for AeroSpace Information (CASI)
7121 Standard Drive
Hanover, MD 21076-1320
(301) 621-0390

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161-2171
(703) 605-6000

Table of Contents

1.0 Introduction	1
2.0 Error Check Criteria	1
3.0 Data fill-in Procedures and Effects	2
4.0 Flags	2
5.0 Summary and Conclusions.....	2
References	3

List of Figures

Figure 1: Flow chart of PREATG subroutine	4
---	---

List of Tables

Table 1: Input Parameters and Valid Ranges	1
Table 2: QA Flags	2

1.0 Introduction

NASA Langley Research Center has been developing and testing the Aircraft VOrtex Spacing System (AVOSS), a set of algorithms, sensor systems and models to assess the behavior of aircraft wakes near the terminal area and to provide safe wake vortex spacing criteria (ref. 1). AVOSS requires some measure of ambient atmospheric turbulence in order to determine important wake characteristics. Two common measures of atmospheric turbulence, eddy dissipation rate (EDR) and turbulent kinetic energy (TKE), were chosen as candidate input parameters. Vertical profiles up to 600 meters are needed. Measurements can only be routinely provided near the surface. Therefore, NASA sponsored the development of the Atmospheric Turbulence Profile Generator (ATPG). North Carolina State University produced software modified by North West Research Associates that generated atmospheric boundary layer turbulence profiles based on classic Similarity Theory (ref. 2). Winds, temperatures, and turbulence measurements at two levels near the ground are the only input requirements. The original modified code was developed and used in a research environment where input parameters could be screened and chosen to ensure validity. Since it was necessary to use this software in a real-time environment with actual measurements of winds, temperatures, and turbulence from an instrumented 43-meter tower, a preprocessor was developed. Real-time data can introduce bad values or crash the program. The strategy was to preprocess inputs in order to provide reasonable data for missing values or for invalid input based on quality assurance criteria. This allowed AVOSS to provide safe spacing during periods of low confidence data.

The purpose of the preprocessor is to check the input parameters to the turbulence profile code to ensure that they are within reasonable ranges and to provide alternatives when necessary.

2.0 Error Check Criteria

Table 1 lists all input parameters needed to generate turbulence profiles and ranges within which the data are expected to fall. Virtual potential temperatures and wind speeds are needed from both the 3 and 10 meter level. In order to tie the theoretical profiles to actual measurements, eddy dissipation and TKE are calculated from fluxpak measurements at altitudes of 5 meters and 43 meters. Missing data due to a sensor malfunction or communications failure at any level, are reported as 9999 and are not allowed to be passed to the ATPG code. The values for the other parameters are based on past measurements and a reasonable expectation of what would constitute a legitimate value for the Dallas-Fort Worth airport where the measurements are obtained. A 43-meter tower provides the platform for all input parameters: wind speeds, temperatures, eddy dissipation and TKE. Thirty-minute averages are used so that a single one-second measurement for the winds and temperatures or the 10 samples per second TKE or EDR would have little affect on the average value. If any of the input measurements fall outside the range (or are missing), then values are filled in or a "canned" profile based on a neutral atmosphere is generated in accordance with a set of rules discussed below and schematically depicted in Figure 1.

Table 1: Input Parameters and Valid Ranges

Parameter Name	Description	Range
THLO	Virtual temperature at 3 meters (K)	At least 263 but not greater than 318
THHI	Virtual temperature at 10 meters (K)	At least 263 but not greater than 318
WSLO	Wind speed at 3 meters (m/s)	At least 0 but not greater than 40
WSHI	Wind speed at 10 meters (m/s)	At least 0 but not greater than 50
TKE5	TKE at 5 meters (m^2/s^2)	At least 0 but not greater than 10
TKE40	TKE at 40 meters (m^2/s^2)	At least 0 but not greater than 10
EDR5	EDR at 5 meters (m^2/s^3)	At least 0 but not greater than 1
EDR40	EDR at 40 meters (m^2/s^3)	At least 0 but not greater than 1

3.0 Data fill-in Procedures and Effects

The logic implemented for the preprocessor is shown in the flow chart in Figure 1. If either the 3- or 10-meter temperature or wind speed is out of range, the other is used as a legitimate substitute. The arbitrary substitution for temperatures forces profiles characteristic of a near-neutral atmosphere. It also exaggerates the stability or instability in the case of no wind speed shear. Both resultant profiles, however, are considered more reasonable than one that would be totally arbitrary. If either TKE or EDR at just one measurement level is missing, the measurement at the other level is used as a fill in. This substitution has little effect on profiles above the tower (43 meters). If temperatures or winds at both 3 and 10 meters are missing, and valid TKE and EDR measurements are available, then the EDR and TKE observed is assumed to be constant with altitude. In that case, a larger value of turbulence would be provided above the tower than similarity theory would predict in all but neutral or very unstable atmospheres. Once again, however, it is assumed to be more representative than an arbitrary profile. If both levels of TKE or EDR are out of range, then profiles will continue to be generated from the measurements from up to three previous time periods. Because a nominal AVOSS data-run is expected every half hour, data up to, but not including, two hours old could be used to generate the profiles. Finally, if there is no valid EDR or TKE at either tower level for two hours or longer, an arbitrary neutral atmosphere TKE and EDR profile is provided.

4.0 Flags

Flags are set to indicate each of the data fill-ins and substitute profiles discussed above. The flags are used by AVOSS to screen low quality data. The seven flags used and their triggers are shown in Table 2. Flags 1 through 4 indicate when any single level EDR or TKE is missing and was filled-in with the measurement from the other tower level. Flag 5 indicates the use of old data (up to three periods) to generate the profiles. Flag 6 indicates the use of constant profiles when temperatures or winds at both levels are missing. Flag 7 indicates use of a default profile generated from a neutral atmosphere.

Table 2: QA Flags

Flag Number	Meaning
1	1 if the 5 meter fluxpac TKE or EDR is out of range
2	1 if the 40 meter fluxpac TKE or EDR is out of range
3	1 if the 3 meter savpac wind or temperature is out of range
4	1 if the 10 meter savpac wind or temperature is out of range
5	1 if the last valid profile is being returned. (less than 2 hours old)
6	1 if returning a constant profile based on TKE and EDR input
7	1 if returning a default (canned) profile

5.0 Summary and Conclusions

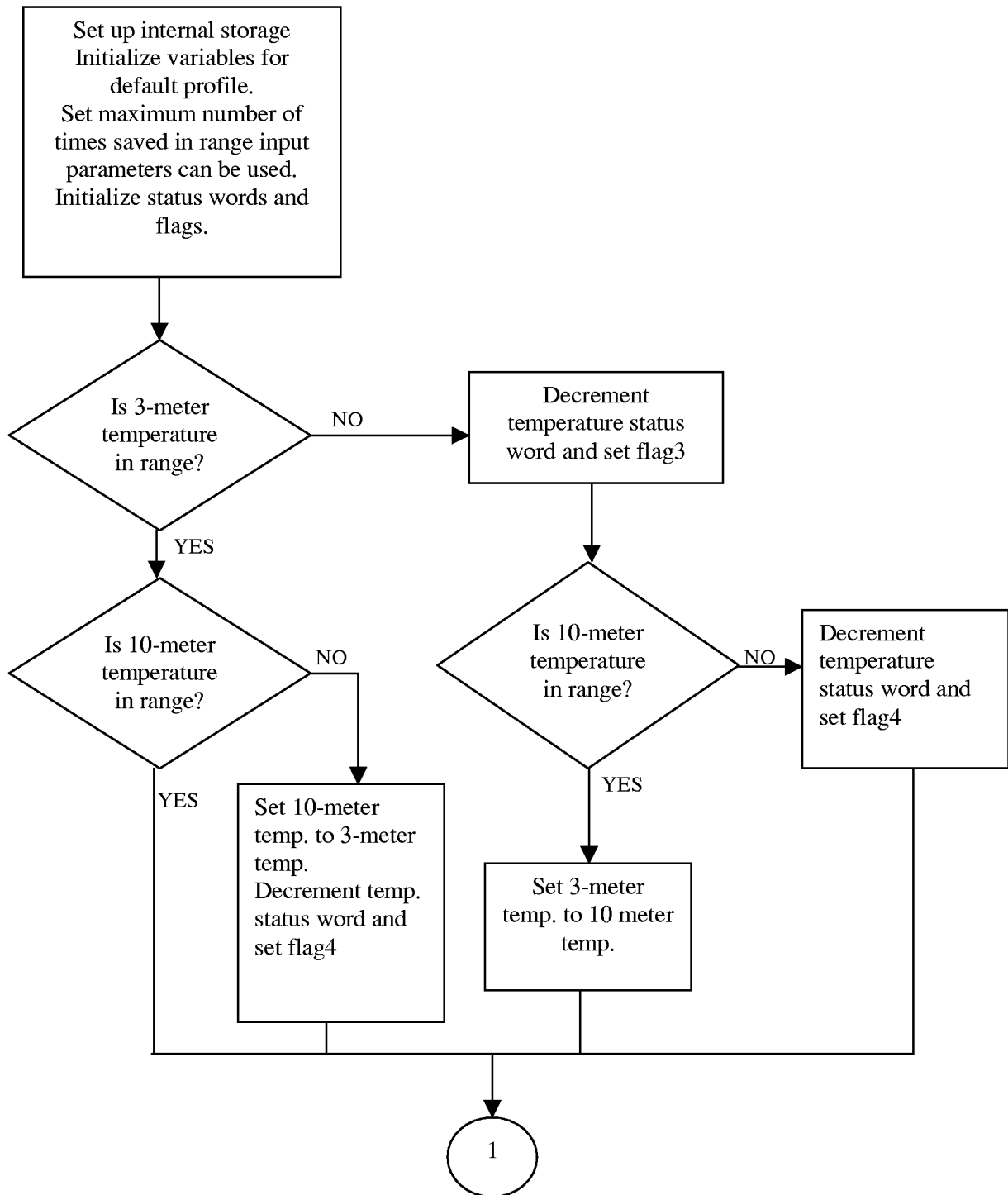
Since AVOSS requires turbulence profiles to appropriately determine aircraft spacing, turbulence profiles must always be produced, even if the result is an arbitrary (canned) profile. The original turbulence profile code was generated and used in a non-real-time environment in the past. All of the input parameters could be carefully selected and screened prior to input. Since this code must run in real-time using actual measurements in the field as input, the field measurements must be checked and screened as part of the real-time implementation. The process described herein is a step towards ensuring that only reasonable input data will be passed to the ATPG code and thus provide the best possible turbulence profiles for AVOSS. Data fill-ins, constant profiles, and default profiles are used only as a last resort, but

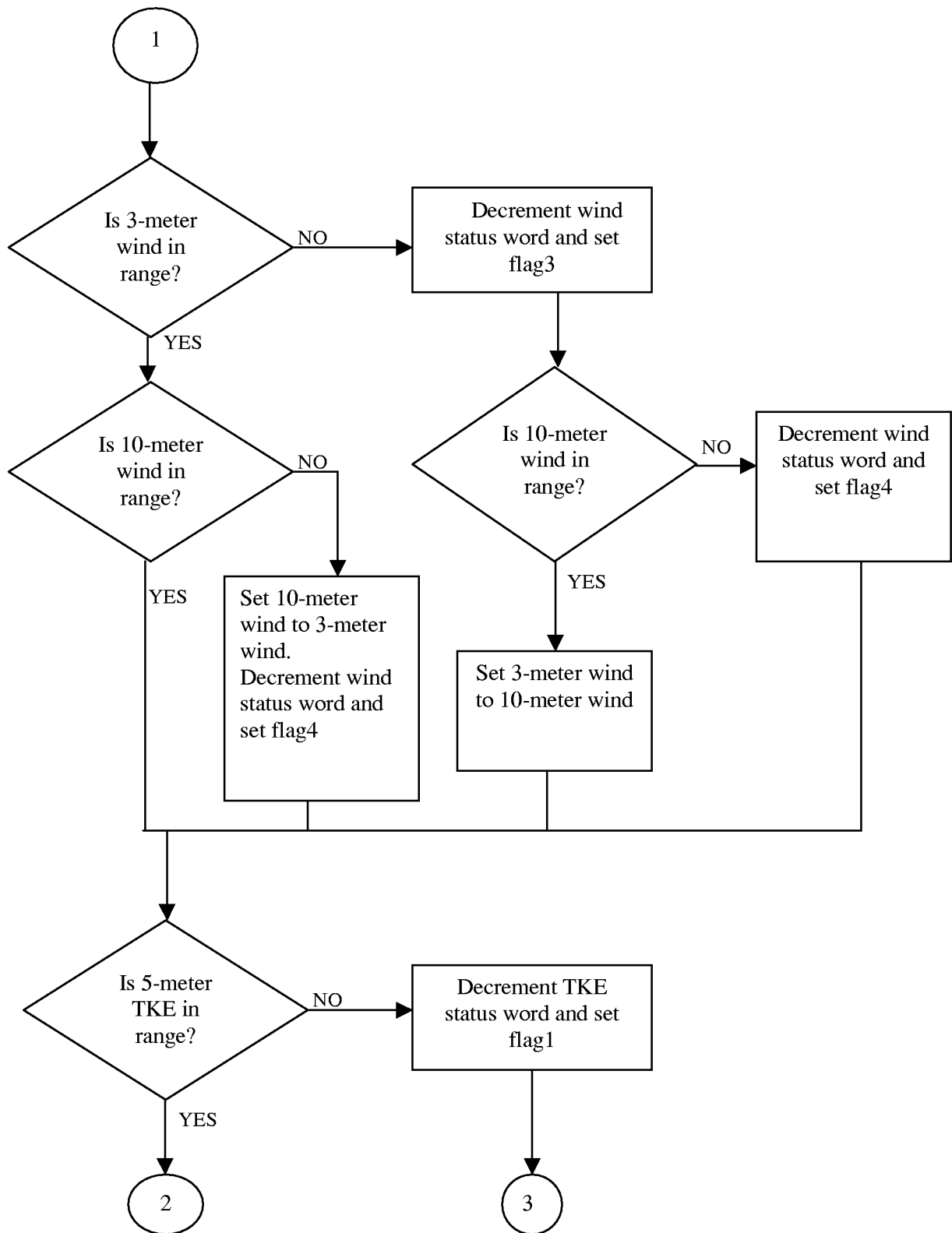
are essential to ensure automated execution of AVOSS.

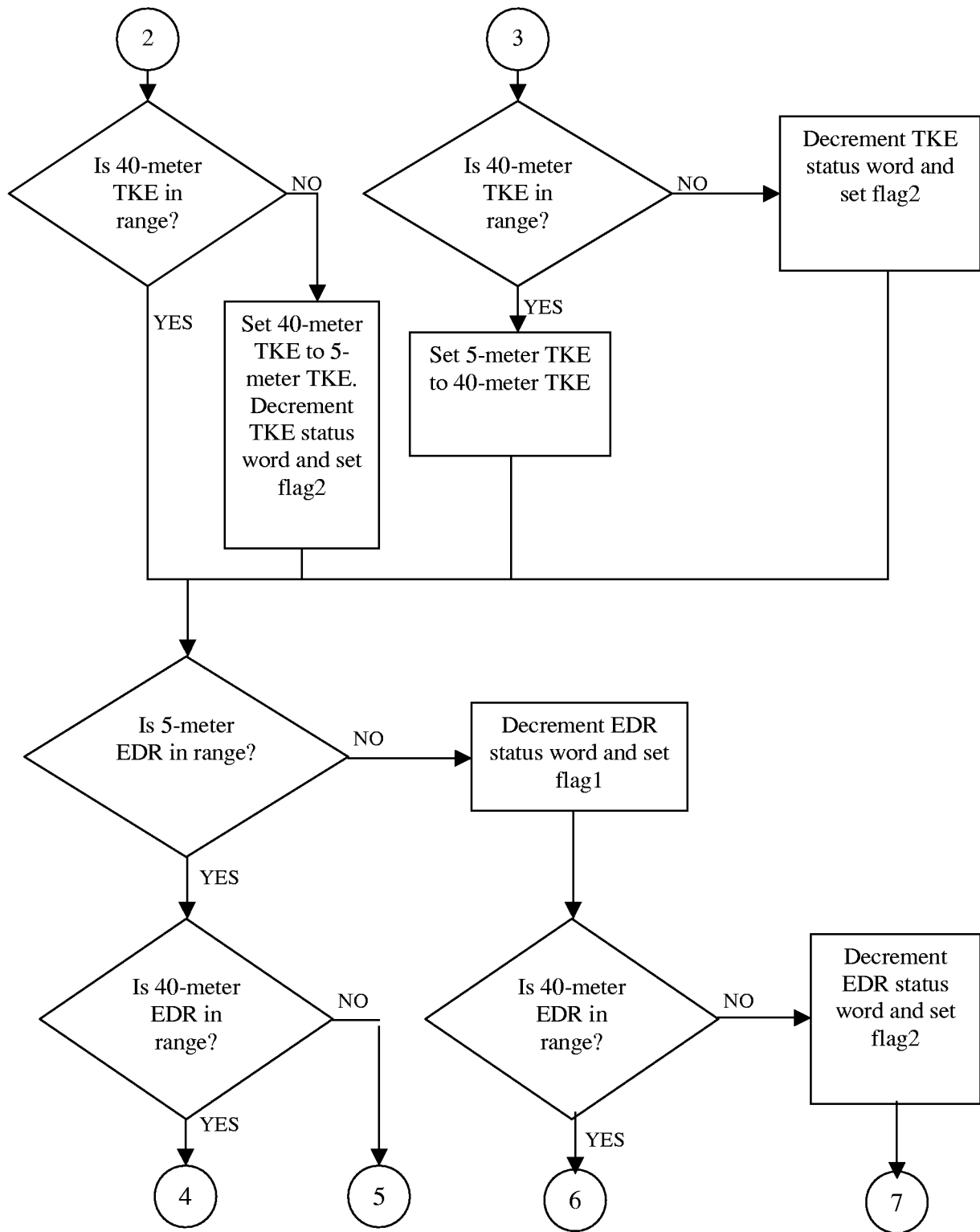
References

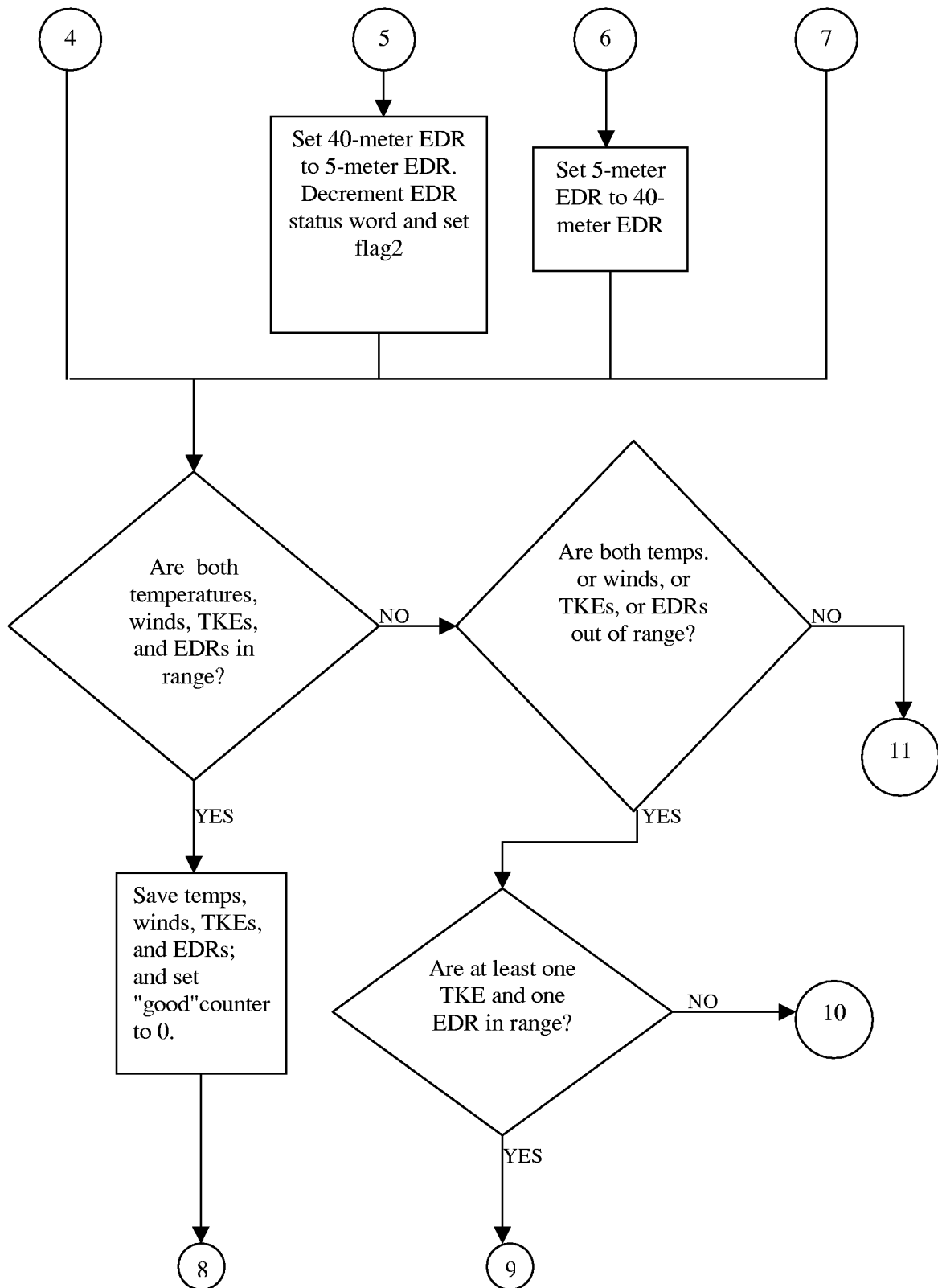
1. Hinton, D. A., 1995, "Aircraft Vortex Spacing System (AVOSS) Conceptual Design", NASA Technical Memorandum 110184, NASA Langley Research Center, Hampton, VA.
2. Han, J., Shen, S. P., Arya, and Lin, Y. L., 2000, "An Estimation of Turbulent Kinetic Energy and Energy Dissipation Rate Based on Atmospheric Boundary Layer Similarity Theory", NASA/CR-2000-210298, June 2000.

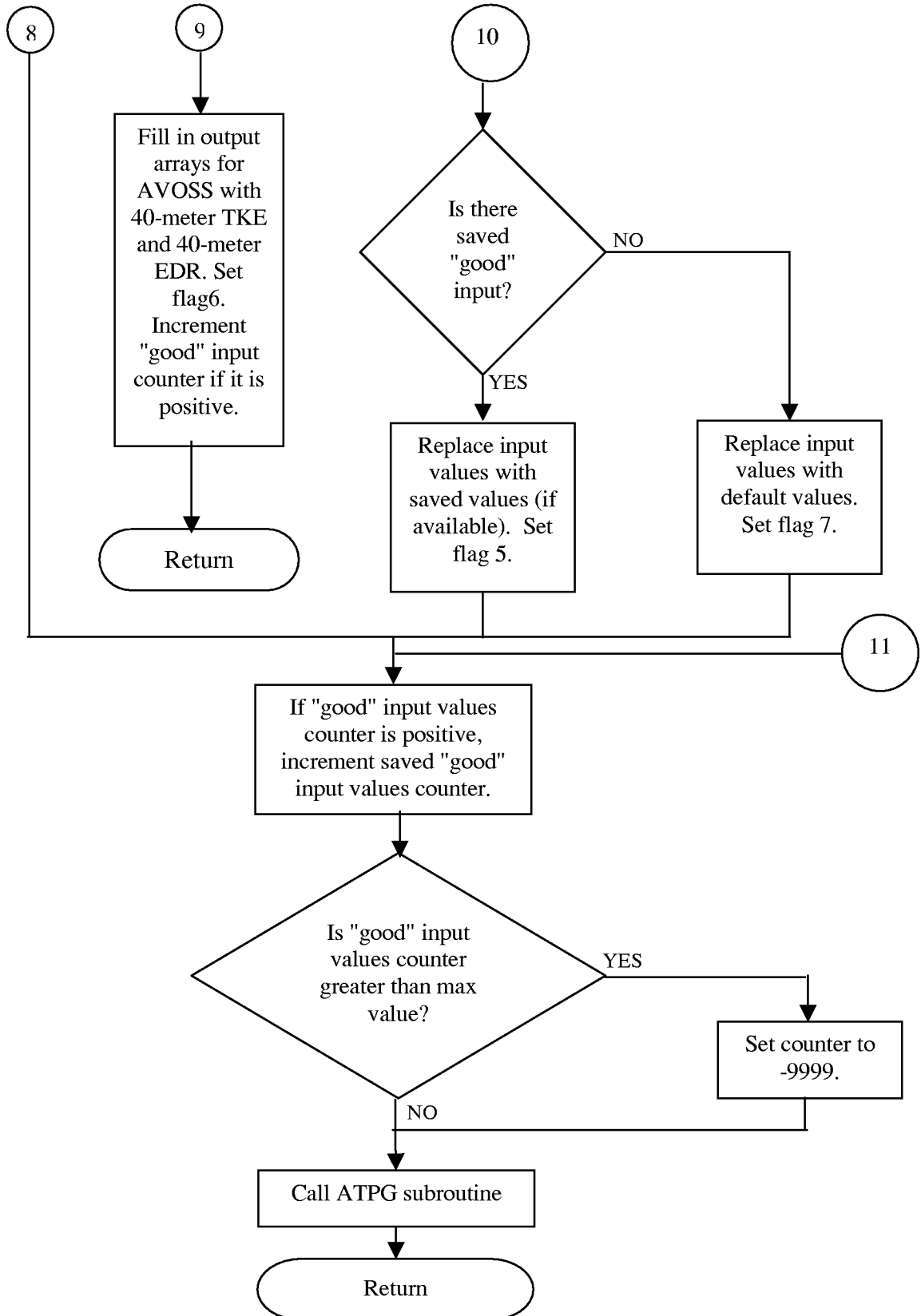
Figure 1: Flow chart of PREATG subroutine.











REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE March 2001		3. REPORT TYPE AND DATES COVERED Contractor Report
4. TITLE AND SUBTITLE Preprocessing for Eddy Dissipation Rate and TKE Profile Generation			5. FUNDING NUMBERS C NAS1-96014 WU 728-40-30-01	
6. AUTHOR(S) J. Allen Zak and William G. Rodgers, Jr				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Vigyan, Inc., Hampton, VA 23666 and Lockheed Martin, Hampton, VA 23681			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Langley Research Center Hampton, VA 23681-2199			10. SPONSORING/MONITORING AGENCY REPORT NUMBER NASA/CR-2001-210834	
11. SUPPLEMENTARY NOTES Langley Technical Monitor: Burnell T. McKissick				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified-Unlimited Subject Category 03 Distribution: Nonstandard Availability: NASA CASI (301) 621-0390			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The Aircraft Vortex Spacing System (AVOSS), a set of algorithms to determine aircraft spacing according to wake vortex behavior prediction, requires turbulence profiles to appropriately determine arrival and departure aircraft spacing. The ambient atmospheric turbulence profile must always be produced, even if the result is an arbitrary (canned) profile. The original turbulence profile code was generated By North Carolina State University and used in a non-real-time environment in the past. All the input parameters could be carefully selected and screened prior to input. Since this code must run in real-time using actual measurements in the field as input, it became imperative to begin a data checking and screening process as part of the real-time implementation. The process described herein is a step towards ensuring that the best possible turbulence profile is always provided to AVOSS. Data fill-ins, constant profiles and arbitrary profiles are used only as a last resort, but are essential to ensure uninterrupted application of AVOSS.				
14. SUBJECT TERMS Aircraft wakes; Wake vortices; AVOSS; Atmospheric turbulence; Turbulence profile			15. NUMBER OF PAGES 14	
			16. PRICE CODE A03	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	